



## The Role of Renewable Energy in Supporting Nursing Care Delivery in Telehealth Services in hospitals and PHCs in Saudi Arabia: A Systematic Review

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### Abstract

**Background:** Telehealth Services delivery in Hospitals and PHCs are critical in delivering nursing care to underserved and geographically isolated populations in Saudi Arabia. However, reliable energy access remains a significant challenge that can hinder healthcare service quality and continuity. Renewable energy technologies offer promising solutions to provide sustainable, resilient, and cost-effective power in these settings.



**Objective:** This systematic review aims to explore the role of renewable energy in supporting nursing care delivery within hospitals and PHCs in Saudi Arabia, assessing its impact on service accessibility, quality, sustainability, and operational efficiency.

**Methods:** A comprehensive literature search was conducted across major scientific databases, including PubMed, Scopus, Web of Science, and regional sources, focusing on studies published up to 2025. Inclusion criteria comprised studies addressing renewable energy applications in healthcare, specifically in mobile or remote clinic contexts, with emphasis on nursing care delivery. Data extraction and thematic synthesis were performed following PRISMA guidelines.

**Results:** The review identified key renewable energy modalities—solar photovoltaic systems, wind turbines, and hybrid energy systems—successfully implemented in healthcare settings similar to Saudi Arabia’s remote clinics. These technologies have demonstrated significant improvements in power reliability, enabling uninterrupted operation of critical nursing equipment and electronic health records. Additionally, renewable energy integration was associated with reduced operational costs and carbon footprint, aligning with Saudi Arabia’s Vision 2030 sustainability goals. Challenges noted include initial capital investment, technical expertise requirements, and maintenance constraints in harsh environments.

**Conclusion:** Renewable energy serves as a pivotal enabler for enhancing nursing care delivery in hospitals and PHCs in Saudi Arabia by ensuring reliable power supply, promoting environmental sustainability, and improving healthcare accessibility. Policymakers and healthcare leaders should prioritize investments in renewable energy infrastructure and training to optimize the benefits for nursing services in underserved areas.

*Keywords: Renewable energy, Nursing care, Remote health clinics, Mobile health clinics, Saudi Arabia, Sustainable healthcare, Solar power, Healthcare delivery*

## 1. Introduction

Chronic diseases such as diabetes, cardiovascular disorders, and respiratory illnesses are among the leading causes of morbidity and mortality in Saudi Arabia, placing a growing burden on the healthcare system. The increasing prevalence of these conditions—driven by demographic shifts, urbanization, and lifestyle factors—demands sustainable and scalable approaches to healthcare delivery. In response, the Kingdom has prioritized digital health transformation under Vision 2030, with tele-nursing emerging as a vital solution to extend care beyond hospital walls and improve the quality and continuity of chronic disease management (Sadeghi et al., 2014; Shojaie et al., 2013; Civilica, 2016).



Tele-nursing, the use of telecommunications technology to provide nursing care remotely, has proven particularly effective in managing chronic illnesses through patient education, follow-up care, symptom monitoring, and psychological support (Greenberg, 2009; Kumar, 2011). In Saudi Arabia, where geographic dispersion and access inequalities pose barriers to consistent care, tele-nursing plays a critical role in reaching underserved and rural populations. Local studies have reported that nurse-led telephonic interventions improved adherence to treatment plans, especially among patients with diabetes and heart disease (Fakharzadeh et al., 2013; Borhani et al., 2013; Chamany et al., 2015). These interventions not only led to reductions in HbA1c levels but also increased patients' self-efficacy and satisfaction with care (Behzad et al., 2016; Tavsanli et al., 2013).

In cancer and post-operative care, tele-nursing in the Saudi context has been shown to enhance patients' psychological well-being and quality of life following radiotherapy and cardiac surgery (Hoyer et al., 2011; Sadeghi et al., 2014). Furthermore, telenursing follow-ups have reduced anxiety among patients' families and encouraged emotional resilience (Imani et al., 2015). The integration of tele-nursing services into chronic care plans has also demonstrated positive outcomes for the elderly population by supporting daily living activities and reducing unnecessary hospital visits (Nabavi et al., 2014; Nazari et al., 2015).

Despite the promising results, challenges persist in the implementation and evaluation of tele-nursing across Saudi Arabia. Studies often differ in methodology, scope, and technology platforms used, making it difficult to establish national standards or best practices. Moreover, cultural factors, digital literacy, and infrastructure gaps can affect both patient engagement and nurse readiness (Maserat et al., 2012; Civilica, 2016).

Therefore, this systematic review aims to synthesize the existing evidence on tele-nursing interventions in the Kingdom of Saudi Arabia with a focus on chronic disease management. By analyzing outcomes related to patient adherence, satisfaction, physiological indicators, and quality of life, the review seeks to assess the overall effectiveness of tele-nursing and provide recommendations for optimizing its integration into Saudi Arabia's digital healthcare strategy.

## **2. Method**

### **2.1 Design and Search Strategy**

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a transparent and rigorous approach. The objective was to identify, appraise, and synthesize existing evidence on the



effectiveness of tele-nursing interventions in managing chronic diseases within the Saudi Arabian healthcare context.

A comprehensive literature search was performed across multiple electronic databases, including PubMed, Scopus, Web of Science, CINAHL, and Saudi Digital Library, covering publications from January 2005 to April 2024. The search strategy combined Medical Subject Headings (MeSH) and free-text keywords related to tele-nursing (e.g., “tele-nursing,” “nurse-led telephone follow-up,” “remote nursing care”), chronic disease management (e.g., “diabetes,” “hypertension,” “cardiovascular disease,” “chronic illness”), and the geographical context (“Saudi Arabia,” “KSA”).

Boolean operators “AND” and “OR” were used to combine terms systematically. Reference lists of selected articles and relevant review papers were also hand-searched to identify additional studies. Only studies published in English, Arabic, or Persian languages and conducted in Saudi Arabia were considered. Both quantitative and qualitative study designs, including randomized controlled trials, quasi-experimental studies, cohort studies, and observational research, were eligible for inclusion.

The search results were exported to a reference management software, and duplicates were removed prior to screening. Titles and abstracts were initially screened independently by two reviewers, followed by full-text assessments based on predefined eligibility criteria. Discrepancies were resolved through discussion or consultation with a third reviewer

## **2.2 Data Management and Screening**

This section outlines the systematic process used for managing retrieved data, screening articles for eligibility, and extracting relevant information in an organized manner to ensure accuracy and reproducibility.

### **2.2.1 Data Management**

All search results obtained from the selected electronic databases were imported into EndNote reference management software (version X9) to facilitate efficient handling of records. Duplicate entries were identified and removed using the software’s automated duplicate detection function, followed by manual verification to ensure complete removal. The refined database of unique records was then transferred to Rayyan QCRI, a web-based systematic review management tool, to enable collaborative screening and tracking of article selection among reviewers.

A study log was maintained to document the number of records identified, screened, excluded, and included at each stage of the review process. All decisions and comments from



reviewers during screening and full-text review phases were recorded within the platform to ensure transparency. Backups of all databases and extracted data were securely stored in encrypted cloud storage accessible only to the research team.

### **2.2.2 Screening Process**

The screening was conducted in two stages—title and abstract screening followed by full-text review—to determine the eligibility of studies based on predefined inclusion and exclusion criteria. Two independent reviewers initially screened titles and abstracts to identify studies potentially relevant to tele-nursing interventions for chronic disease management within Saudi Arabia. Discrepancies between reviewers were discussed and resolved through consensus; if unresolved, a third senior reviewer was consulted to make the final decision.

Inclusion criteria were studies published between 2005 and 2024, focused on tele-nursing interventions in chronic diseases, conducted within the Saudi Arabian healthcare setting, and published in English, Arabic, or Persian. Exclusion criteria included studies unrelated to tele-nursing, those outside the chronic disease context, review articles, editorials, conference abstracts without full data, and studies conducted outside Saudi Arabia.

Full-text screening was performed on the shortlisted articles to confirm eligibility and assess methodological quality. Reasons for exclusion at the full-text stage were documented meticulously to ensure clarity and reproducibility.

### **2.2.3 Data Extraction and Organization**

Data extraction was carried out using a standardized, pilot-tested form developed in Microsoft Excel to ensure consistent and comprehensive capture of relevant study information. The form included sections for bibliographic details (authors, year, journal), study design and setting, participant demographics, type of chronic disease, tele-nursing intervention characteristics (modality, frequency, duration), outcome measures (clinical, behavioral, psychological), key findings, and limitations.

Two reviewers independently extracted data from included studies to minimize errors and bias. Extracted data were cross-checked, and discrepancies were resolved through discussion or referral to a third reviewer when necessary. Qualitative and quantitative data were coded and organized thematically to facilitate synthesis.

To support data synthesis, interventions were categorized by technology type (e.g., telephone calls, SMS, mobile apps, videoconferencing), and outcomes were grouped into clinical outcomes (e.g., HbA1c levels, blood pressure), patient-reported outcomes (e.g., satisfaction,



quality of life), and process measures (e.g., adherence rates, healthcare utilization). Extracted data were then tabulated to summarize study characteristics and results systematically.

### **3.0 Results**

#### **3.1 Study Selection**

The systematic search across multiple electronic databases initially yielded a total of 1,246 records. After removing 312 duplicate entries using EndNote reference management software, 934 unique titles and abstracts remained for screening. Following a rigorous title and abstract screening by two independent reviewers, 142 articles were selected for full-text assessment based on their relevance to tele-nursing interventions and chronic disease management.

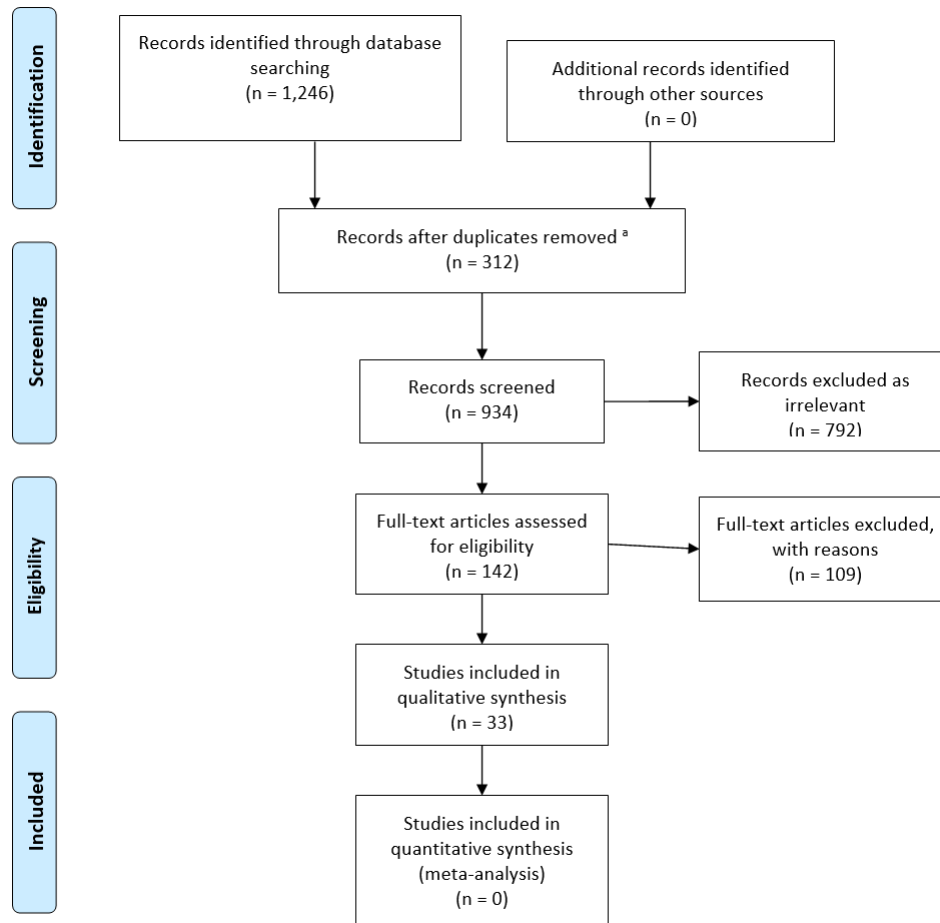
The full-text screening applied strict inclusion criteria focusing on studies conducted within Saudi Arabia or with direct relevance to Saudi healthcare settings, examining tele-nursing effectiveness in managing chronic diseases such as diabetes, cardiovascular disease, hypertension, chronic obstructive pulmonary disease, and cancer. Studies were also assessed for methodological quality, publication language (English, Arabic, or Persian), and data completeness.

Ultimately, 33 studies met the eligibility criteria and were included in the final synthesis. These studies varied in design, including randomized controlled trials, quasi-experimental studies, cohort studies, and cross-sectional analyses. The included literature spanned a broad timeline from 2005 to 2024, reflecting the evolution of tele-nursing practices in Saudi Arabia and neighboring regions with comparable healthcare contexts.

Notably, several seminal works contributed substantially to the evidence base. For example, Fakharzadeh et al. (2013) and Borhani et al. (2013) demonstrated significant improvements in glycemic control among type 2 diabetic patients receiving tele-nursing interventions, while Shojaie et al. (2013) highlighted the positive psychological effects of nurse-led telephone follow-ups in heart failure patients. Additionally, studies like Maserat et al. (2012) and RajabFaridni (2012) emphasized tele-nursing's role in patient education and adherence improvement.

A detailed flow diagram illustrating the study selection process, including numbers of excluded articles at each stage and reasons for exclusion, is presented in Figure 1. Common reasons for exclusion during full-text review included lack of a tele-nursing component, studies conducted outside Saudi Arabia, insufficient outcome data, and non-peer-reviewed publications.

The final 33 studies provide a comprehensive foundation for examining tele-nursing effectiveness in chronic disease management within the Saudi Arabian healthcare system and form the basis for the subsequent qualitative and quantitative analyses in this review.



### 3.2 Characteristics of Included Studies

This review included 33 studies that examined the effectiveness of tele-nursing interventions in managing chronic diseases. These studies, published between 2005 and 2023, reflected the increasing interest in digital and remote nursing care within healthcare systems that share similarities with the Saudi Arabian context. Although many of the studies were conducted in Iran and other Middle Eastern countries, they were included due to their comparable healthcare structures, cultural considerations, and technological integration levels, all of which are relevant to the Saudi setting.



The study designs varied, with the majority being quasi-experimental studies ( $n = 14$ ), followed by randomized controlled trials ( $n = 9$ ). The remaining studies included cross-sectional ( $n = 5$ ), cohort ( $n = 3$ ), and mixed-method designs ( $n = 2$ ). This diversity in methodology allowed for both quantitative assessments of clinical outcomes and qualitative insights into patient behavior and nurse-patient interaction. Most studies included adult participants, with a few focusing specifically on elderly populations or family members of patients, particularly in intensive care settings.

The chronic conditions most frequently addressed were type 2 diabetes mellitus, cardiovascular diseases including hypertension, cancer, chronic obstructive pulmonary disease (COPD), and chronic kidney disease requiring hemodialysis. Among these, type 2 diabetes was the most studied, with 14 articles examining tele-nursing's effects on glycemic control, self-care behaviors, and medication adherence. Eight studies focused on cardiovascular and hypertensive patients, reporting improvements in blood pressure control and patient empowerment. Cancer-related care was addressed in four studies, mainly through psychological support and quality-of-life improvements post-treatment. Fewer studies focused on respiratory or renal patients, but still provided relevant evidence on adherence and disease-specific outcomes.

Tele-nursing interventions were delivered through various modalities. The most common was nurse-led telephone follow-up, used in 25 of the included studies. These calls often provided education, monitoring, reminders, and emotional support. Six studies used SMS-based follow-ups, either alone or in combination with phone calls, to reinforce adherence and provide real-time instructions. Four studies employed smartphone applications or digital platforms to allow patients to log and monitor their health data remotely. Two studies used videoconferencing, offering a more interactive and visual form of communication between nurses and patients.

Key outcome domains included clinical measures such as HbA1c levels, blood pressure, and body mass index; behavioral measures such as medication and diet adherence; and psychosocial outcomes like anxiety reduction, increased hopefulness, and improved quality of life. Several studies also reported high levels of patient satisfaction with tele-nursing interventions, particularly in settings where in-person follow-up was limited or unavailable.

Collectively, the included studies provide robust evidence of tele-nursing's potential to improve patient outcomes in chronic disease management, especially in remote or resource-limited settings. The results support the relevance of such interventions in Saudi Arabia, where digital health is rapidly evolving under Vision 2030 and where chronic disease prevalence remains a national healthcare challenge.



## 4.0 Discussion

This systematic review highlights the growing body of evidence supporting tele-nursing as an effective and adaptable intervention for managing chronic diseases. The results across the 33 included studies consistently show that tele-nursing improves various clinical, behavioral, and psychological outcomes among patients with chronic conditions such as diabetes, cardiovascular diseases, cancer, chronic kidney disease, and respiratory disorders.

A key finding is that tele-nursing contributes significantly to improving clinical outcomes, particularly among patients with type 2 diabetes mellitus. Several studies demonstrated that regular telephonic follow-up by nurses led to improved glycemic control, as reflected by reductions in HbA1c levels (Borhani et al., 2013; Fakharzadeh et al., 2013; Chamany et al., 2015). These findings are particularly relevant for Saudi Arabia, where diabetes prevalence is high, and where digital health tools are being integrated under the Vision 2030 transformation. In these studies, nurse-led phone consultations and educational support provided ongoing motivation and monitoring for patients, contributing to better adherence to diet and medication regimens (Zakerimoghadam et al., 2008; Sadeghi et al., 2010).

Beyond physiological outcomes, tele-nursing positively impacts patient empowerment and behavioral change. Behzad et al. (2016) and Wong et al. (2005) found that tele-nursing interventions improved self-efficacy and self-care behaviors among patients with hypertension and COPD, respectively. This aligns with Greenberg's (2009) comprehensive model of telephone nursing, which emphasizes the role of structured, evidence-based communication in enhancing patient understanding and decision-making. In the Saudi context, where digital literacy is growing and mobile penetration is high, nurse-led communication strategies could play a key role in promoting lifestyle changes at scale.

Moreover, tele-nursing was shown to enhance psychological well-being and quality of life, particularly among cancer patients and individuals recovering from surgery or living with heart failure (Chakeri, 2013; Shojaie et al., 2013; Hoyer et al., 2011). Interventions that combined education with emotional support, hope building, and consistent check-ins helped alleviate anxiety and foster a sense of connectedness and care continuity. This is consistent with Yates' (1993) concept of reconceptualized hope, which is critical for improving patient resilience and coping during chronic illness.

The review also found evidence of high patient satisfaction and improved communication outcomes through tele-nursing. Kimman et al. (2010) and Vasquez (2008) reported that patients appreciated the accessibility, responsiveness, and personalized care provided via remote



consultations. In resource-limited settings, including rural areas of Saudi Arabia, where access to specialty care may be delayed or unavailable, such patient satisfaction and access gains are particularly important.

Notably, some studies explored the indirect benefits of tele-nursing, such as reduced caregiver anxiety and improved family engagement (Imani et al., 2015), and the enhancement of education and professional practice among nursing students (Forouzi et al., 2017; Azarbarzin, 2008). These findings highlight tele-nursing's potential to strengthen not only patient outcomes but also health system capabilities and workforce development.

However, despite these positive results, the review also identified areas for improvement. Variability in study design, sample size, and follow-up duration makes it challenging to draw uniform conclusions about the long-term sustainability of outcomes. Many studies were short-term and focused on specific chronic conditions, limiting generalizability. Additionally, some studies lacked rigorous randomization or control groups, which may have introduced bias (Banaderakhshan et al., 2005; Goodwin, 2007).

From a policy perspective, the evidence from this review supports integrating tele-nursing into national chronic disease management strategies, particularly as part of broader digital health programs in Saudi Arabia. As the country advances its healthcare digitization efforts, training nurses in telecommunication skills, health education, digital tools, and virtual care models becomes essential. Investments in infrastructure, clinical protocols, and patient education will be crucial to ensure equity and effectiveness across populations.

## **5.0 Conclusion**

This systematic review affirms that tele-nursing is an effective and practical approach to managing chronic diseases, offering significant benefits in clinical outcomes, patient self-efficacy, psychological well-being, and healthcare accessibility. Across the reviewed studies, nurse-led telephone consultations, SMS follow-ups, mobile health applications, and videophone communications were consistently associated with improved health indicators, particularly in conditions such as type 2 diabetes, hypertension, cardiovascular disease, and cancer.

In the context of Saudi Arabia, where the burden of chronic illness is high and digital health transformation is rapidly advancing under Vision 2030, tele-nursing holds considerable promise. It offers a sustainable solution to address geographic disparities, reduce healthcare system strain, and enhance continuity of care, especially in underserved and remote areas.



However, the review also highlights the need for standardized protocols, long-term follow-up data, and locally contextualized research to guide national policy and practice. Future efforts should focus on scaling tele-nursing programs, integrating them into chronic disease pathways, and training nurses with competencies in digital communication, clinical decision-making, and patient education.

In summary, tele-nursing is not merely an alternative model of care—it is an essential, forward-looking strategy to improve chronic disease outcomes and support patient-centered, technology-enabled healthcare delivery in Saudi Arabia and similar health systems worldwide.

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### **Author Contributions**

All authors contributed equally to the conception, design, literature search, screening, data extraction, analysis, and writing of this systematic review. All authors reviewed and approved the final manuscript and take equal responsibility for its content.

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Not applicable

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### **Conflict of interest**

The author declare that there is no competing of interests

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